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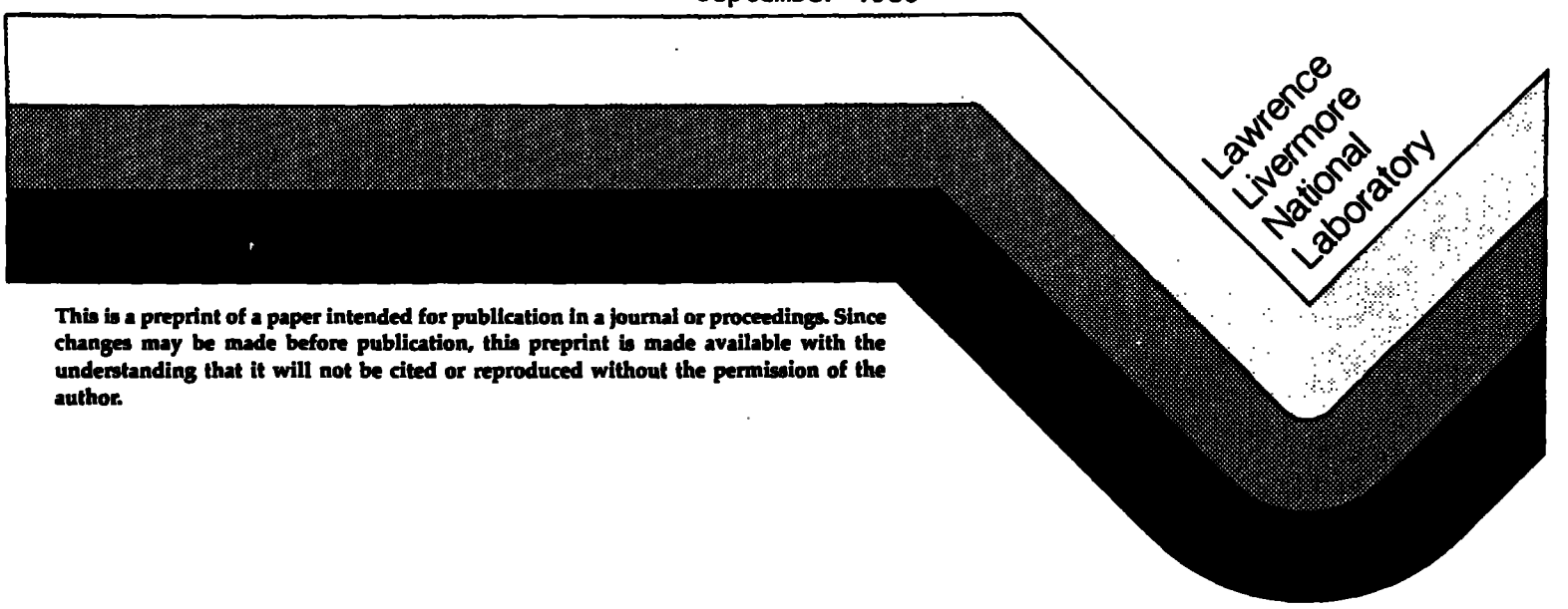

Geologic and Geophysical Investigations of Mid Valley at the NTS

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Abstract

The exploration strategy employed in the investigation of Mid Valley, a partially enclosed basin west of the C. P. Hills, is presented. Prior geologic mapping and limited geophysical work by the USGS suggested that Mid Valley should be investigated as a possible new test area. Detailed analyses of the existing data types were conducted. Questions which still remained after these analyses were identified and an exploration program was designed to specifically address these issues. Two exploratory holes - totaling 2128 metres - were drilled in conjunction with 5.6 km of seismic reflection lines using an air gun seismic source. No Paleozoic tags were obtained from the drill holes.

Preliminary analyses of the drill holes, gravity, and seismic data indicate a deep block-faulted north-trending graben structure. The combined alluvium-tuff section may exceed 1500 metres in the deeper parts of the trough. Depths to static water level in the two drill holes ranged from 502 to 508 metres.

Intervals of poorly consolidated alluvium were found in both holes. Hole stabilization methods are presently under review. The alluvium and volcanic medium characteristics appear similar to previous test experience in Yucca Flat and Pahute Mesa. The full results of this investigation will be reported in detail in another LLNL publication.

The Lawrence Livermore National Laboratory (LLNL) Nuclear Test Containment Program was starting to examine possible new areas for testing at the Nevada Test Site (NTS) during 1982. At the same time, the LLNL Test Program wanted to find an area suitable for advanced concept test. The requirements for this area included:

1. be near Yucca Flat support facilities
2. accomodate yield to 100 kt max cred with an occasional larger test
3. have working points (WP) above the static water level (SWL)
4. have WP in tuff
5. be away from other large Yucca Flat tests
6. be at lower elevations than Pahute Mesa for easier winter operation

These requirements came from the desire to have a testing area for events which would have a long residence time in the field. This leads directly to the requirements for being away from other large tests which would interfere with the more delicate advanced concept tests and for operating at lower

elevations than Pahute Mesa where severe winter weather exists. The economics of testing dictated the other requirements. This paper documents how the LLNL Containment Program explored for an area which would meet these requirements. The complete results of this investigation will be reported in a separate publication that will be printed shortly.

We started the process by reviewing the existing geologic and geophysical data about remote Yucca Flat areas and other nearby surrounding NTS areas. The data types examined included geologic maps, hydrology data (SWL maps), seismic refraction and reflection data, aeromagnetic data, and surface gravity data. All data types did not exist for all areas examined. However, for each data type, we reviewed other researchers' interpretation of the data, if it existed, or we made some quick back-of-the-envelope interpretation of that data ourselves. This effort was greatly aided by the excellent review that the USGS had done in 1977 on real estate availability at the NTS [1].

Based upon this review, we tentatively identified the Mid Valley region of the NTS as a candidate for the advanced concept test site (Figure 1). Approximately 21 square miles of area that had a topographic slope of less than 10% that fit our other criteria appeared to exist. A large uncertainty existed over the SWL in Mid Valley. No water wells existed in Mid Valley at the time. SWL projections were based upon SWL data from Yucca Flat and Jackass Flat wells. However, it appeared that the SWL was over 1500 ft. and could be as much as 2000 ft. A limited seismic refraction data set indicated that the alluvium section in the deeper parts of the basin was about 1000 ft. thick. However, the seismic refraction data only covered a very small portion of the basin. No conclusions about alluvium thicknesses elsewhere or tuff section thicknesses anywhere could be reached from this data type.

The surface Bouguer gravity data were studied. The gravity low in this area definitely indicates a closed basin. Before attempting to invert the data for structure, we examined to see whether the regional gravity stations spacing would be adequate for also determining structure with some detail. The gravity station spacing in Mid Valley is on a regional basis; hence stations are not spaced on a regular grid with a 1000 or 500 ft spacing as is the case in Yucca Flat (Figure 2). However, surface gravity fields tend to be smooth and thus are spatially correlated over some distance. We used the geostatistical technique, kriging, to determine whether additional gravity stations would add very much new information about the gravity field. We assumed that the original gravity values were error-free in this prediction process and then calculated the field at other places in Mid Valley along with the associated uncertainty in the predicted values (Figures 3 and 4). Except the southwest portion of Mid Valley, the field can be predicted from the existing data to an accuracy which exceeds the uncertainty in the original Bouguer values. Hence we concluded that obtaining additional surface gravity data at this time would not significantly increase our knowledge of structure in Mid Valley.

In addition, we knew very little about the densities of the overburden in Mid Valley. Thus we inverted the surface data along several profiles using a 2-D inversion code several times using density contrasts between the overburden and the underlying Paleozoic ranging between 0.35-0.75 gm/cc. Using a density contrast of 0.7 gm/cc (a typical value for Yucca Flat), we found that the basin was deep enough to accomodate the size of test we wanted to place in Mid Valley (Figure 5).

Using the geologic maps and the other types of geophysical data along with the 2-D gravity inversions, we reviewed some existing preliminary Mid Valley geologic cross sections and drew several others in other portions of Mid Valley. This was done mainly to help us decide if enough area would be available for testing to warrant further investigations in Mid Valley. We concluded that the southern portion of Mid Valley (about 12 square miles) held great promise of being the area needed for the advanced concept tests. The LLNL Test Program after reviewing our data and considering the economics of developing a new area agreed that further exploration of the Mid Valley area was warranted. The Mid Valley area was then selected as the initial site for the Cottage event.

The next phase of the investigation was to drill an exploratory hole and field a seismic reflection survey. The two key remaining unknowns that the exploratory hole was to determine were the Paleozoic depth and the SWL. In addition, velocity data for interpretation of the seismic reflection data along with a full set of logs, samples, and cores were to be obtained. The seismic reflection program was designed to determine the structure in the southern portion of Mid Valley in the area we had decided held the most promise.

The seismic reflection program consisted of three long lines that crossed the entire valley and was fielded using air gun seismic sources. This was the first time that these sources had been employed at the NTS for seismic surveying. We decided to use these sources to obtain the data after considering the economics and the practicality of these sources for NTS terrain. Hindsight says we made a good decision. These sources have proved to be a most practical and efficient source for seismic work at the NTS. The data obtained in Mid Valley and Yucca Flat has been excellent.

An exploratory hole was sited to investigate the deepest part of the basin. We modified the initial location slightly in order to permit the drilling to proceed with a minimal amount of surface preparation. We also crossed our fingers that we had selected the best location for investigating and answering the questions we had about Mid Valley. The exploratory hole, Ue14a, was drilled to 1006 m; no Paleozoic tag was obtained. The drilling was terminated because of sloughing problems. Dual string drilling techniques were not employed on this hole. During and after drilling, a complete set of geologic samples were obtained. These included cuttings, cores, and gun sidewalls from the exploratory hole and outcrop samples from around the valley.

The initial exploratory hole, Ue14a, and the seismic reflection survey demonstrated that the area had great potential. A second exploratory hole, Ue14b, was sited in a location which was to be the emplacement site for the Cottage event. Ue14b was drilled to 1122 m; no Paleozoic tag was obtained. However, an additional suite of log, samples, cores, and cuttings were obtained to further refine our understanding of the Mid Valley location.

The lithologic contact logs from the exploratory holes show a normal stratigraphic sequence; the thicknesses of the units determined by drilling is also confirmed at the holes and is determined elsewhere by the seismic reflection data. In the deeper parts of the basin, between 250-375 m of alluvium overlay the volcanic section. The stratigraphic column in Mid Valley is more complete than in Yucca Flat; this is because Mid Valley is closer to

the source regions for many of the lithologic members. However, the units seen in Mid Valley that are not present in Yucca Flat have been seen and examined in detail on Pahute Mesa. No completely new lithologic units were discovered. Petrologic and geochemical analyses aided greatly in the identification of many of the contacts.

The density logs were particularly revealing. As opposed to Yucca Flat where the average density of the volcanic units ranges between 1.8 to 2.0 gm/cc, the density logs in Mid Valley indicate that the average density of the volcanic units is around 2.2 gm/cc. This explains why our initial estimates from inversions of surface gravity data gave Paleozoic depth estimates which are too shallow. We believe that the density contrast between the Paleozoic material and the overburden was about 0.7 gm/cc. However, the logs indicate that the density contrast is much lower, probably around 0.4 gm/cc. This means that the structure interpreted from the surface gravity data had depths which were too shallow. This was confirmed by the two drill holes as we never reached the Paleozoic rocks.

The velocity surveys run in the two exploratory holes using a Vibroseis source were used to convert the seismic reflection data from time to depth sections. Some extrapolation of the time-depth data was necessary to obtain estimates of the Paleozoic surface from the seismic sections. The seismic sections clearly indicate the zones of large major faulting (Figure 6). It is also observed that the valley contains many numerous small faults. This is not unusual because the newer high quality LLNL reflection data in Yucca Flat also show the same type of faulting. While some portions of the sections are unclear, the major structural features (large faults and bed thicknesses) are clearly seen.

Based upon the results from the drilling and the seismic reflection program, we then identified the portion of Mid Valley which would suitable for the advanced concept tests. An area was submitted for environmental clearance, a necessary step before testing can proceed. The area that has been identified is a little smaller than was initially thought that Mid Valley could accomodate. However, the basin is much deeper than was initially thought. Larger tests could be sited here than previously thought.

While we are still putting together our final report from our studies, some of the findings which have significant impact upon the containment and fielding of a nuclear event are known. Of particular importance are the following:

Mid Valley in the deeper parts of the basin has:
- a deep block-faulted north-trending graben structure.
- a static water level greater than 500 m.
- an alluvium section thickness between 300-400 m.
- a volcanic section thickness greater than 700 m.
- a Paleozoic depth greater than 1200 m and possibly exceeding 1500 m.
- alluvium this is tuffaceous for depths greater than 30 m.

The last point about the alluvium has serious implications for the drilling feasability im Mid Valley. The alluvium being essentially all tuffaceous material is not cemented very well. In UeI4b, a significant amount of near surface hole enlargement was encountered. It is difficult to state whether the enlargement occurred because of drilling technique or because of

natural sloughing. Hole stabilization may be necessary in order to construct a large diameter emplacement hole.

Where are we presently? We believe that, from a geologic standpoint, Mid Valley is a viable test area. LLNL will publish shortly all findings from these exploratory studies. We have only tried to give this symposium a feeling for the type and level of effort that has gone into investigating this area. From almost every viewpoint that we have examined, the alluvium and volcanic section in Mid Valley appear very similar to previous test experience in Yucca Flat and Pahute Mesa.

References

1. Fernald. A. T., Real Estate Availability Study, Potential New Test Areas, Nevada Test Site, U.S. Geological Survey, January, 1977.

Acknowledgments

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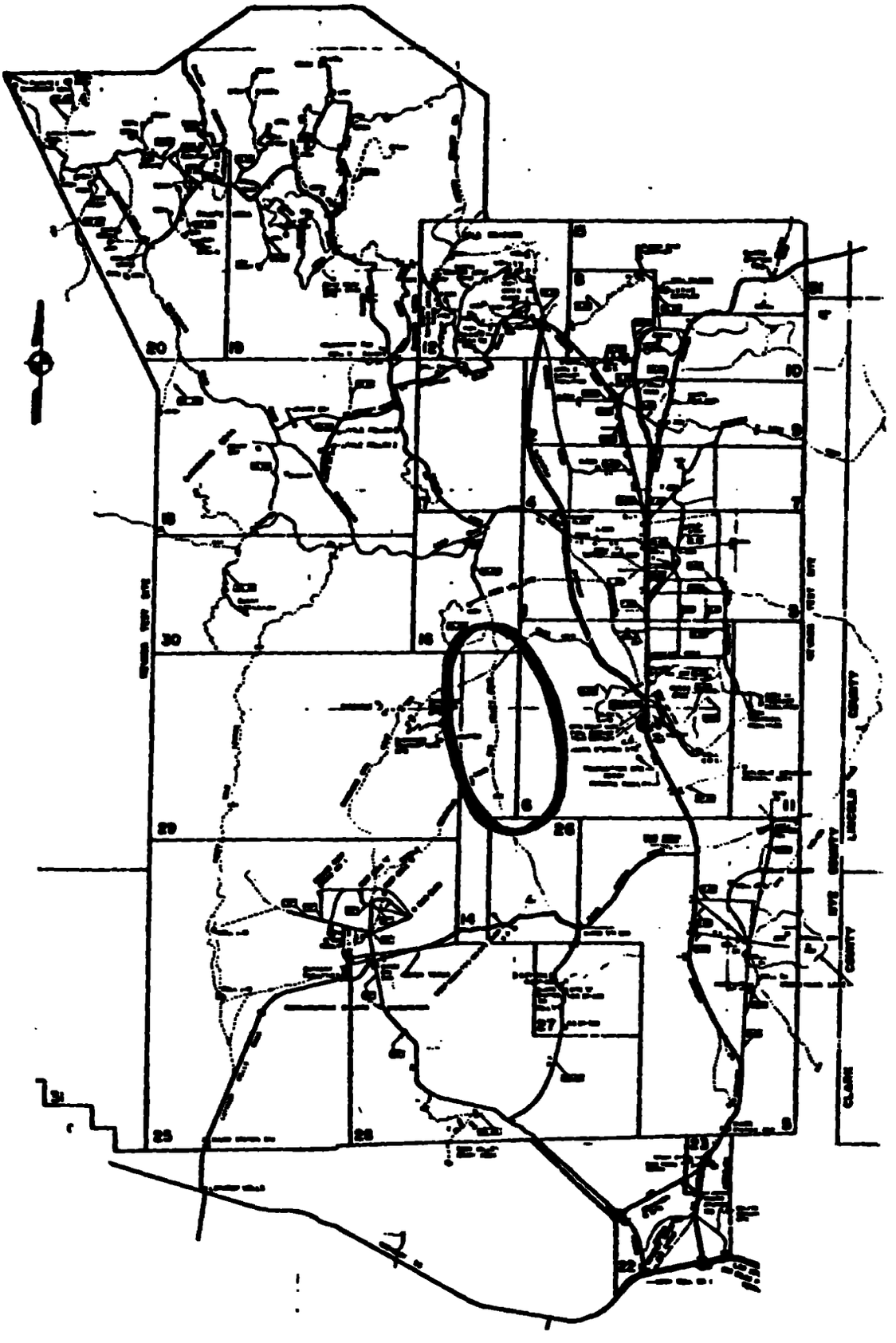

Figure 1. Map of the Nevada Test Site. The circled area is Mid Valley, a portion of Areas 6 and 14.

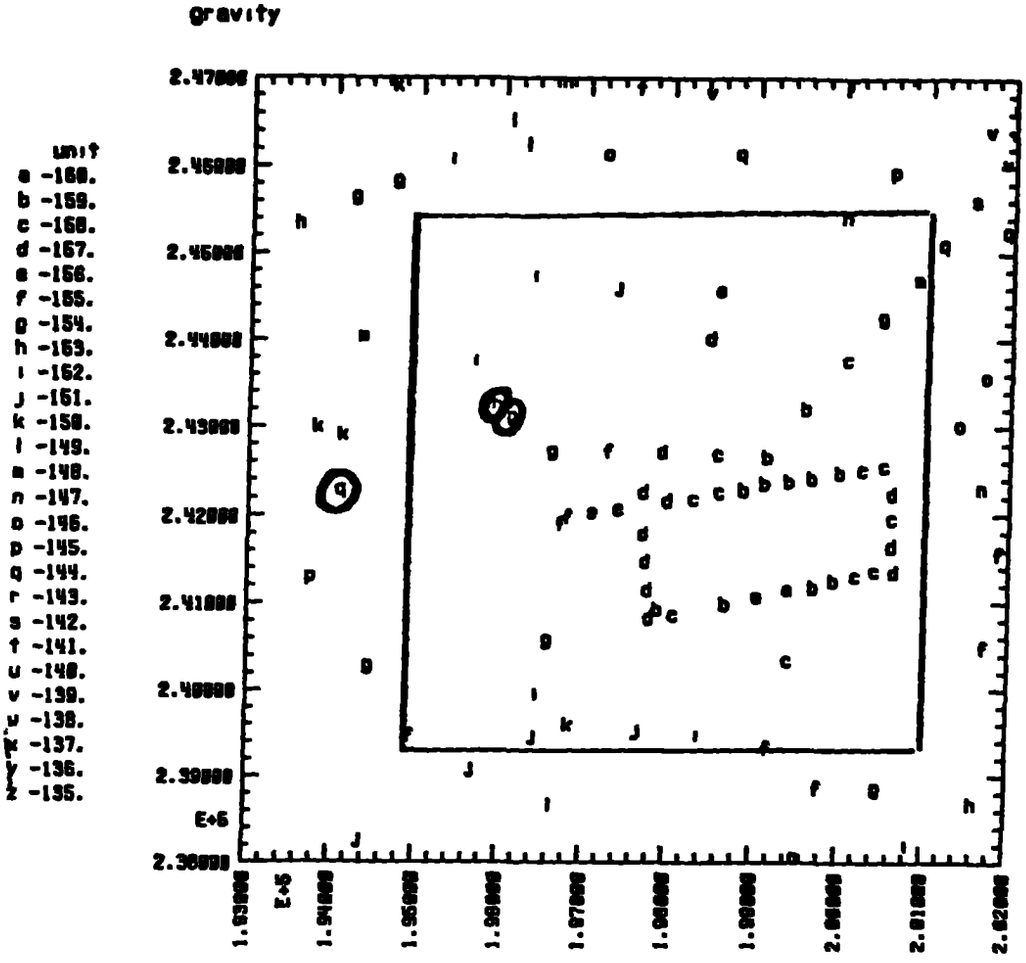

Figure 2. The distribution of surface gravity stations in the Mid Valley region. The inner square of stations is in the southern portion of Mid Valley, the region of primary interest. The circled stations appear anomalous and may be in error.

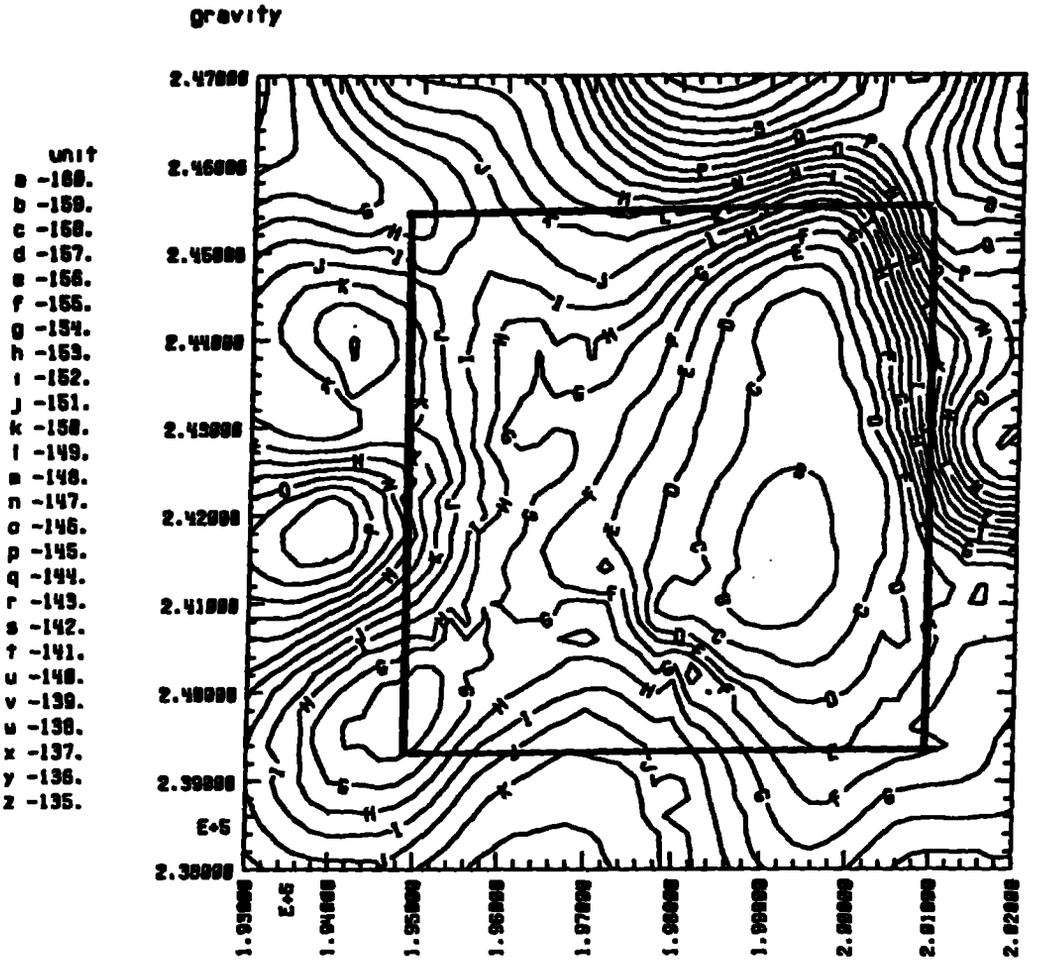

Figure 3. Contours of Bouguer gravity in Mid Valley after kriging was performed on the data distribution shown in Figure 2.

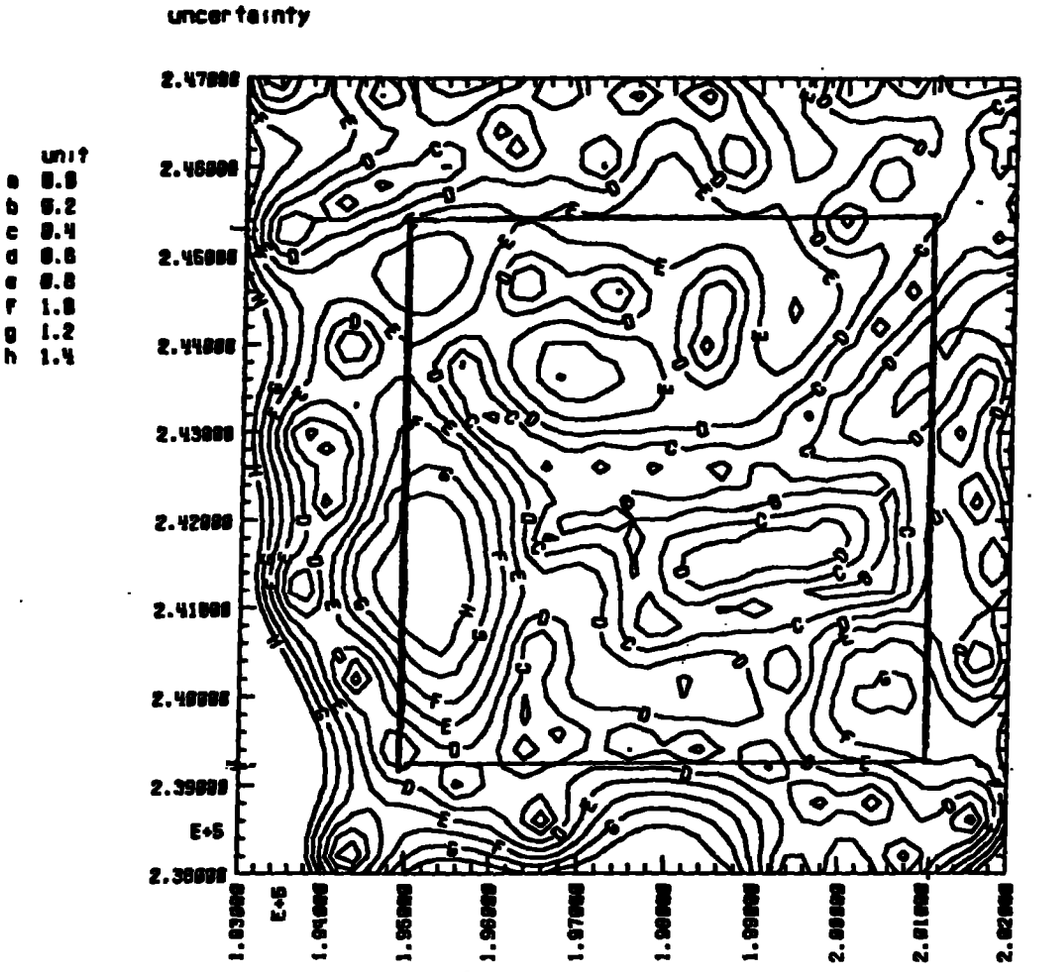

Figure 4. Uncertainty in the kriged gravity shown in Figure 3.

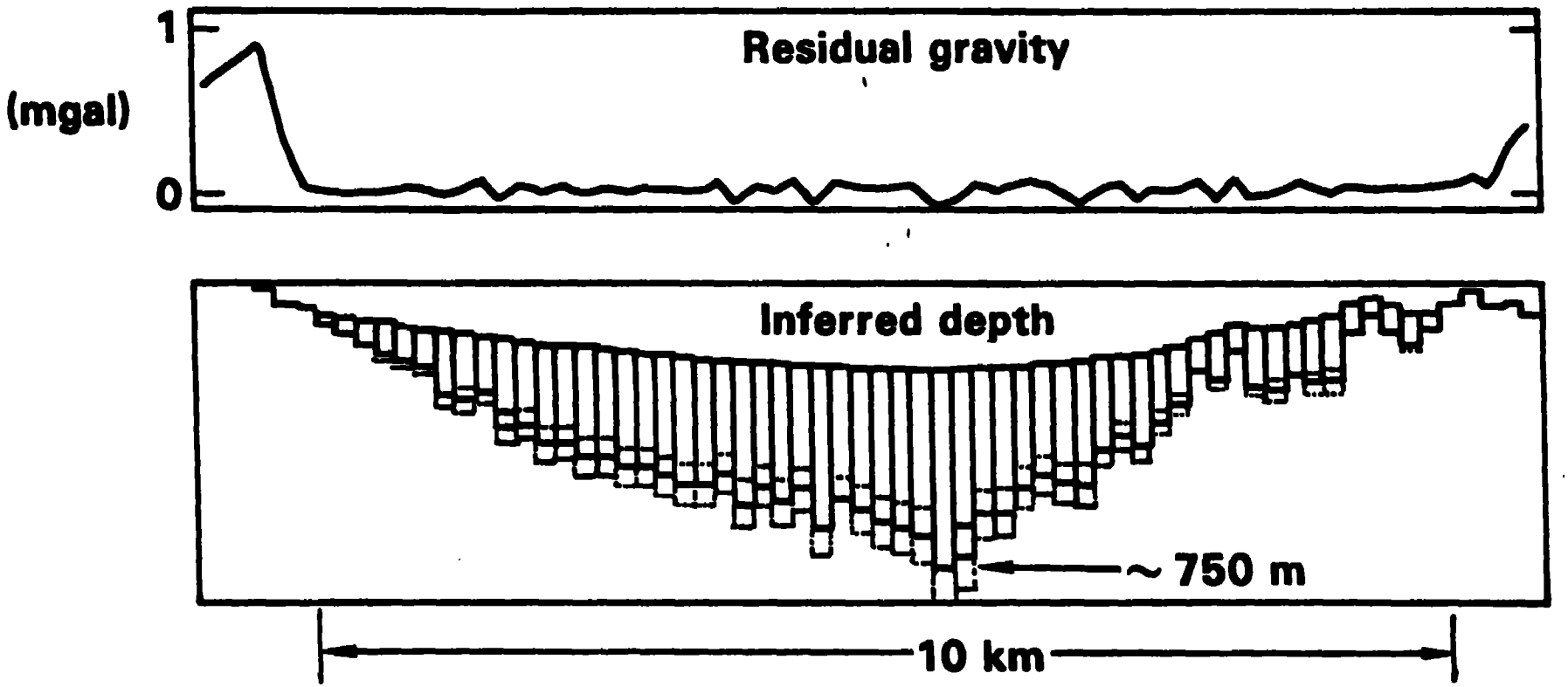

Figure 5. Typical 2-D gravity inversion using a density contrast of 0.7 gm/cc.

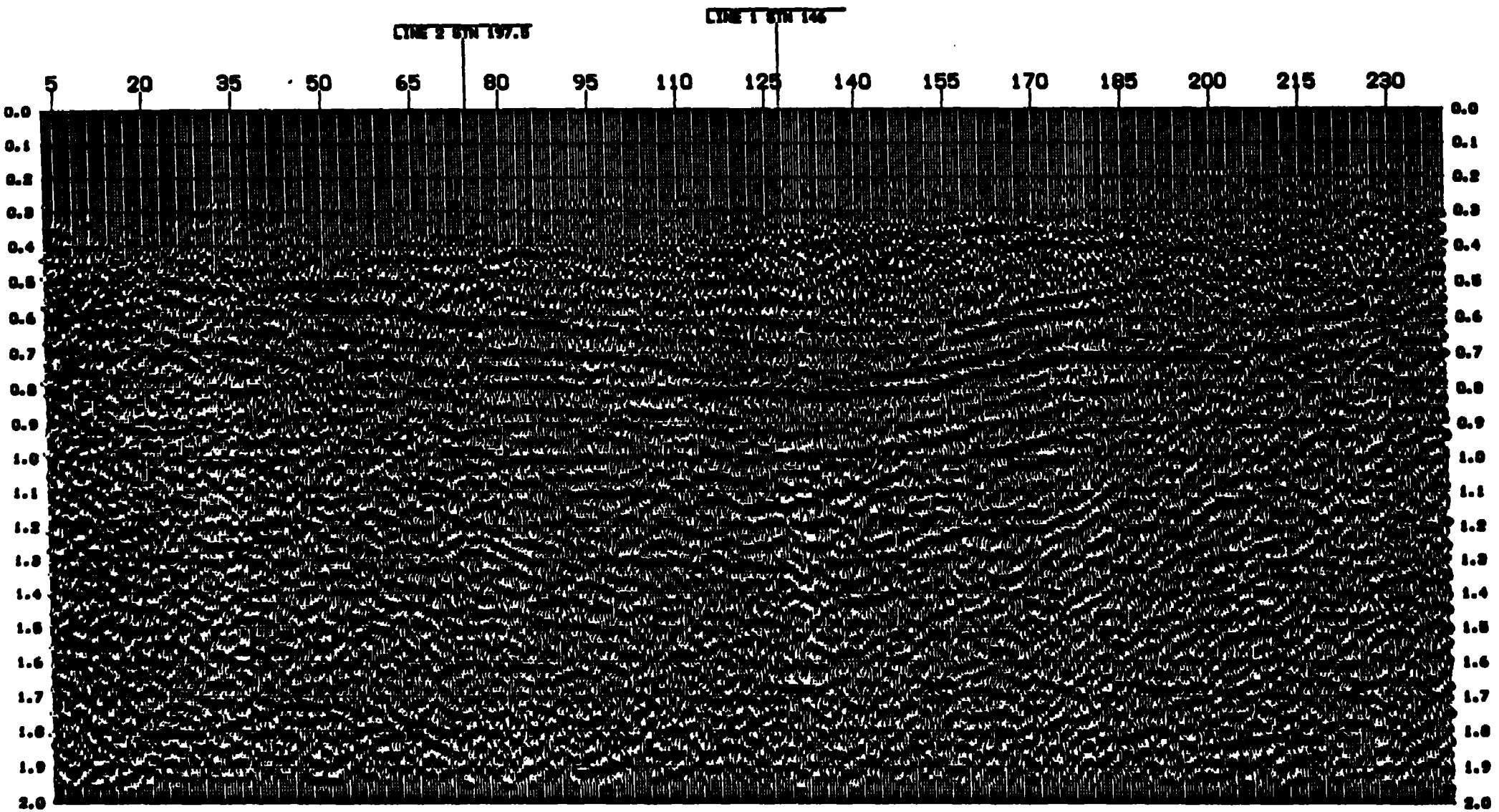

Figure 6. Seismic section from Mid Valley. Line of section runs approximately north-south.